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AUTHOR Gilbride, Kathleen E.; And Others
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ABSTRACT

To determine whether deficits warranting intervention are present in the later functioning of high-risk infants, 22 premature infants who experienced asphyxia or chronic lung disease (CLD) but who had no gross developmental abnormalities were evaluated. Assessments of auditory perception and receptive language ability were made during later childhood (ages 4 to 8 years). A total of 21 age-matched children born at term with no complications composed the comparison group. High-risk subjects were found to be significantly inferior to the comparison subjects in discriminating auditory tones, perceiving rapid auditory sequences, and exhibiting receptive language skills. CLD subjects were found to be significantly inferior to asphyxia subjects only in receptive language skills. It was concluded that these deficits in later childhood indicate the need to monitor high-risk infant development despite the absence of gross delays. (Author/RH)

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High-Risk Infants: Auditory Processing Deficits in Later Childhood

Kathleen E. Gilbride
University of Utah

Robert M. Kaplan
San Diego State University
University of California, San Diego

Paula Tallal
University of California, San Diego

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Abstract

This study evaluated 22 premature infants who experienced asphyxia or chronic lung disease (CLD) but no gross developmental abnormalities. Assessments of auditory perception and receptive language ability were made during later childhood (age 4-8 yrs.). Twenty-one age-matched children, born at term with no complications comprised the comparison group. High-risk subjects were significantly inferior to the comparison subjects in discriminating auditory tones, perceiving rapid auditory sequences, and receptive language skills. CLD subjects were significantly inferior to asphyxia subjects in receptive language skills only. These deficits in later childhood indicate the need to monitor high-risk infant development despite the absence of gross delays.

High-risk Infants: Auditory Processing

Deficits in Later Childhood

Survival of high-risk infants has steadily increased over the last few decades while morbidity rates have declined (Drillien, 1958; Rawlings, Reynolds, Stewart, & Strang, 1971). The incidence of gross developmental abnormalities such as cerebral palsy, mental retardation, or visual handicaps is relatively low (10%) due to modern medical technology which has improved neonatal intensive care (Stewart & Reynolds, 1974). It is not clear, however, the extent to which neonatal complications influence later functioning in childhood. Deficits may not be apparent until after certain abilities have begun to develop (e.g., language, memory, abstract thinking). Follow-up and intervention of high-risk infants may be discontinued if no gross deficits are evident by preschool age (3-4 yrs.). The lack of early gross delays does not preclude deficits in later abilities such as language processing and auditory perception.

The purpose of this study was to determine whether deficits warranting intervention are present in later functioning of high-risk infants. Previous research has found deficits in language development of premature children (Rubin, Rosenblatt & Balow, 1973). Therefore, receptive language ability and auditory perception were assessed in a group of "high-risk" infants (defined as premature, low birthweight and prolonged hospitalization) who had reached preschool or school age with no significant developmental abnormalities. Children who experienced one of two specific complications, chronic lung disease (CLD) or asphyxia, were studied in order to control for number of complications and to assess the effects of two relatively common complications of premature infants.

Method

Subjects. Thirty-seven children (4-8 yrs.) were selected from a population of high-risk infants and children participating in the Neonatal Follow-up Clinic at Children's Hospital & Health Center, San Diego, CA. All subjects were born prematurely

and admitted to the neonatal intensive care unit at Children's Hospital shortly after birth. Conditions of selection were: 1) diagnosis of chronic lung disease, bronchopulmonary dysplasia or Wilson-Mikity syndrome (all forms of CLD) requiring respiratory therapy or 2) diagnosis of asphyxia neonatorum, defined by a 1-min. Apgar score ≤ 5 or a 5-min. Apgar score ≤ 7, and resuscitation via bag and mask or endotracheal intubation. Children experiencing other significant complications (CLD plus asphyxia, blindness, deafness) were excluded. Fifteen subjects were lost to follow-up, leaving 11 in each of the CLD and asphyxia groups; mean gestation and birthweight were 31 weeks, 1357 gms, and 33 weeks, 1840 gms, respectively. Twenty-one comparison subjects were taken from a pool of normative data obtained in a previous study with normal children (Tallal, 1981). Subjects were matched according to age and nonverbal intelligence scores. Stark and Tallal (1981) point out the importance of matching groups on the basis of nonverbal intelligence when comparing children with possible language dysfunction to children with normal language functioning. Comparison subjects experienced normal term births with no complications.

Apparatus. The Repetition Test (Tallal & Piercy, 1973) was used to assess auditory perception. It consists of a tape-recording of two 75 msec. complex tones of frequencies within the speech range. Tone 1 had a fundamental frequency of 100 Hz and tone 2 had a frequency of 305 Hz. Tones were generated with three formant (F) frequencies: F1 was 497 Hz, F2 was 750 Hz, and F3 was 1500 Hz. The tape was played for the subject in a quiet room, and subject's responses were made on two depressible panels mounted one above the other on a small metal box.

In addition, the Token Test (De Ronzi & Vignolo, 1962) was used to assess receptive language comprehension; no verbal response is required from the subject. Paper tokens varying in size, color, and shape are arranged on a table in predetermined order. Subjects are asked to pick up or perform simple tasks with them, such as "Put the red circle on the green triangle." Scoring is based on subjects' ability to follow commands; age norms are available for children from three years of age.

Procedure. Each subject was tested on the Repetition Test by the same examiner,

who was formally trained to administer the test. Subjects were trained to respond to either of the two 75 msec. tones, when presented separately, by pushing the lower panel on the response box to tone 1 and the upper panel to tone 2. Discrimination training was continued for a maximum of 48 trials or until a criterion of 20 correct responses in a series of 24 consecutive stimuli was reached. Failure to reach criterion resulted in termination of the test, as adequate discrimination ability is essential to the sequencing tasks. Subjects who succeeded on this task were trained to respond to each of four two-tone stimulus patterns by pushing the panels in the correct sequence. The method was demonstrated four times by the examiner, which preceded eight training trials in which information of results and correction of errors were given.

Following these eight trials, 24 trials without information of results were given. During the first 12 trials an intersound interval (ISI) of 500 msec. was employed, while ISIs of 30 and 70 msec. were randomly varied during the second 12 trials.

The subtests described above are referred to by the authors as "perceptual tests." Subjects who successfully completed them were then given "serial memory" subtests. The same two 75-msec. tones were used with the ISI constant at 500 msecs. The procedure was the same except that the stimulus patterns were longer, consisting of three, four, five, six or seven elements composed of random combinations of the two complex tones. The patterns were presented in a sequential order, and failure on one of these patterns precluded administration of the subsequent patterns. Thus auditory memory as well as perception was assessed.

Subjects received reinforcement (self-adhesive stickers which could be mounted on paper) on a variable ratio schedule (1 to 6 reinforcements every 1 to 6 trials), except that those trials to which the subject responded incorrectly were not reinforced.

Within approximately 2 weeks of taking the Repetition Test, the experimental subjects were seen at home and given the Token Test and the Performance Scale of

the WPPSI or the WISC-R. The purpose of these tests was to assess the subject's level of receptive language, and nonverbal intelligence.

Comparison subjects had been previously administered the Repetition Test using the same procedure as described above. In addition, the Token Test and the WPPSI or WISC-R had been given, yielding a measure of receptive language as well as Full Scale and Performance Scale IQs for these subjects (Tallal et al., 1981).

Results

The dependent measures for the data analysis were Repetition Test scores and Token Test scores. Since the group sizes were unequal, the design became non-orthogonal. To correct for this problem, the least squares solution for analysis of variance was employed. Comparisons between means were accomplished using the method of planned comparisons. Planned comparisons over traditional uses of analysis of variance were used because they feature tests of specific relationships within the data (Lindman, 1974). The comparisons made were (1) between the high-risk groups and the comparison group, and (2) between the two high-risk groups (CLD and asphyxia). See Table 1 for mean scores.

All subjects in each group reached criterion on the initial training trials. On the discrimination tasks, the comparison group scored significantly fewer errors that the high-risk groups (F 1/42 = 18.57, $p < .001$) (See Table 2). No difference was found between the high-risk groups on this task. No differences existed between groups on the first sequencing task when the sequence of tones was presented at relatively long ISIs. On the second sequencing task, the high-risk groups were inferior to the comparison group (F 1/42 = 4.54, $p < .05$), suggesting their greater difficulty in processing tones at more rapid rates. There were no differences for the memory subtests involving more than three elements. Comparison subjects overall completed more tasks on the Repetition Test than did the high-risk subjects.

Analysis of variance of the subjects' performances on the Token Test demon-

strated a significant difference between groups. The first contrast showed that the high-risk groups performed significantly more poorly than the comparison group (F 1/42 = 6.45, $p < .02$). The second contrast was also significant (F 1/42 = 6.09, $p < .02$), indicating that the high-risk groups differed from each other, with the performance of the CLD group being inferior to that of the asphyxia group.

Discussion

The present study found a significant difference in auditory perception and receptive language skills between prematurely-born children with neonatal histories of CLD or asphyxia and normal term birth children. There were no differences in intellectual functioning. The difference between groups' performances on the Repetition Test was seen on the discrimination task and the temporal sequencing task composed of the shorter ISIs. Approximately half of the high-risk subjects were unable to discriminate between the two tones presented randomly in the discrimination task. Those who did successfully complete this task performed as well as the comparison subjects on the temporal sequencing task involving the long ISIs, but demonstrated inferior performance when presented with rapid sequences. These results indicate the presence of specific deficits in processing of rapidly changing acoustic tones as well as in language comprehension (demonstrated by performance on the Token Test).

We cannot draw a causal relationship between the specific neonatal complication experienced and these deficits observed in later childhood. However, the present findings indicate that despite the absence of developmental abnormalities, deficits that warrant intervention can occur in later functioning. Continued follow-up of such children is needed to determine whether these deficits are the result of developmental delay or permanent disability, as well as the extent to which they are responsive to remediation.

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TABLE 1

Mean Scores for Dependent Measures According to Group

Variable	Groups					
	CLD		Asphyxia		Control	
	M	N[a]	M	N[a]	M	N[a]
Repetition Test[b]						
Association	5.46	11	4.82	11	.19	21
Sequencing I	2.67	6	.33	6	.95	21
Sequencing II	5.50	6	4.83	6	3.14	21
Serial Memory						
3	1.33	6	.33	6	1.29	21
4	3.25	4	2.17	6	1.94	17
5	5.67	3	6.20	5	4.23	13
6	10.00	1	7.00	1	4.00	2
Highest subtest completed	Seq. II		Serial Memory 3		Serial Memory 5	
Token Test[c]	495		500		502	
WPPSI or WISC-R Perf. I.Q.	98		106		105	

[a]N is the number of subjects reaching criteria on Repetition Test

[b]Repetition Test scores reflect number of errors

[c]Token Test scaled scores used

TABLE 2

SUMMARY OF ANALYSIS OF VARIANCE

VARIABLE	OMNIBUS (df = 2/42)		CONTRAST 1 (df = 1/42) (ASPHYXIA & CLD)/2 ≠ CONTROL		CONTRAST 2 (df = 1/42) ASPHYXIA ≠ CLD	
	F	p <	F	p <	F	p <
REPETITION TEST						
ASSOCIATION	9.32	.001	18.57	.001	.16	NS
SEQUENCING I	2.55	NS	.43	NS	2.25	NS
SEQUENCING II	2.36	NS	4.54	.05	.19	NS
SERIAL MEMORY						
3	1.16	NS	.80	NS	1.53	NS
4	1.50	NS	1.95	NS	1.52	NS
5	.59	NS	1.01	NS	.04	NS
HIGHEST SUBTEST COMPLETED	5.86	.01	11.53	.002	.20	NS
TOKEN TEST	6.27	.004	6.45	.02	6.09	.02
WPPSI PIQ	1.59	NS	.57	NS	2.61	NS